Maricopa Association of Governments

Technical Memorandum No. 1

INFRASTRUCTURE DEVELOPMENT COSTS

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INFRASTRUCTURE DEVELOPMENT COSTS

INTRODUCTION

The costs associated with development and growth have not been too well identified or estimated. To provide a basis in estimating these costs, a study was completed to estimate at a planning level the infrastructure required to serve a growing population. This study looked at the infrastructure required for water, wastewater, and solid waste facilities. The basis of the study was population and an estimate was made as to the facilities required in each service area. Once the particular facilities were identified, the capital costs to construct the facilities were estimated. These are described below.

APPROACH

The approach used in estimating the costs of infrastructure development was to develop costs based on population, and the unit of population selected was per 1,000. To determine the estimated costs two methods were used. For the water distribution system and the wastewater collection system, individual communities were contacted to determine the total length in miles of water lines and sewer lines in the cities. This was then related to the year 2000 total population served, and from this data the sewer and water lengths per 1,000 population were estimated. The data was also analyzed to determine the typical length of each size of sewer and water line per the 1,000 population.

For the other parts of the water and sewer systems, such as treatment plants, pumping stations or storage tanks, the costs of providing these items for a “typical” community of 100,000 were estimated. These costs were then reduced to produce the cost per 1,000 population.

For solid waste capital costs, contacts were made with several communities to determine costs.

All of these items are discussed in more detail below.

WASTEWATER SYSTEM

The wastewater system for any new area consists of the

- Collection System
- Treatment Facilities
- Effluent Reuse/Disposal System

Collection System

A collection system consists of the sewers located in the streets which collect the wastes from the individual houses and developments along the street. These sewers are the smallest in the system, and most communities now require a minimum size of 8-inches in diameter. These local sewers transport the sewage to larger mains, which in turn connect to the large interceptors flowing to the treatment plant. Table 1, Typical Sewer System Per 1,000 Population, lists the diameters and lengths of the sewers for a typical collection system for each 1,000 in population.

Table 1 Typical Sewer System Per 1,000 Population
MAG Technical Memorandum– Infrastructure Development Costs

Diameter (inches)	Length (feet)	Unit Cost ($/lin foot)	Total Cost ($)
8	14,177	40	$567,080
10	1,323	50	66,150
12	798	60	47,880
15	662	75	49,650
18	416	90	37,440
21	378	105	39,690
24	284	120	34,080
27	236	135	31,860
30	189	150	28,350
33	170	165	28,050
36	104	180	18,720
42	95	210	19,950
48	85	240	20,400
Total	**18,916**		**$989,300**

The diameters and lengths listed in Table 1 are based on an analysis of the sewer systems in Glendale, Phoenix, Mesa, Tempe and Scottsdale. In this analysis, the total length of sewers were measured and compared to the year 2000 population served. This gives a composite total length of sewer per 1,000 population for each community, and it ranged from 2.85 miles per 1,000 people for Glendale to 4.82 miles for Scottsdale. The average for all of the communities was 3.58 miles or 18,916 feet per 1,000 population. This information was further analyzed to look at the breakdown by sewer size to generate a typical sewer length by diameter per 1,000 population. As can be seen in the table, the most common size of sewer is the small local 8-inch diameter.

The unit costs in the table are based on typical 2001 costs for sewer installation around the metropolitan area.

In most communities, where the land is relatively flat, several lift stations will be required as part of the collection system. In analyzing the data from the cities, it was estimated that a lift station was required for every 29,000 in population. Or putting it another way, 0.023 lift stations were required for every 1,000 in population. Assuming the lift station capacity in a community is 5 mgd, this works out at $22,850 per 1,000 population.

Combining the sewers and lift stations, the collection system costs are approximately $1,012,000 per 1,000 population.

Treatment

To meet future growth in the area, the communities are constructing Water Reclamation Facilities (WRF). Generally, these WRFs are being constructed in sizes ranging from 5 to 20 mgd capacity. For the purposes of this analysis, a 10 mgd plant will be assumed which could handle a population of about 100,000 using a per capita flow of 100 gallons per day (gpcd). The 100 gpcd is higher than the average domestic flow but it does include an allowance for commercial and industrial contribution.

The level of treatment from these plants is advanced with nitrogen removal giving an effluent quality of Class A or even Class A+, which are suitable for unrestricted irrigation. Components in the plant are activated sludge, filters and UV disinfection. Sludge would be treated on-site aerobically and disposed of at a landfill.

Capital costs for such a plant run about $5 per gallon capacity for a total plant cost of about $50 million, including the land. The prorated share for the 1000 population is therefore about $500,000.

Effluent Reuse/Disposal

The effluent from the WRFs is extremely valuable for irrigation and for groundwater recharge. Typically, an effluent system consists of a pump station, effluent distribution system and aquifer storage/recovery (ASR) wells. There may also be effluent storage tanks. In the summer the effluent would be used for irrigating golf courses, parks, school green areas as well as other landscaping. During wet or winter months, the effluent would generally be recharged for storage.

Costs for a 10 mgd system are estimated to be:

Pump Station	$1,400,000
Distribution System	6,394,000
ASR Wells	6,000,000
Total	**$13,794,000**

On this basis, the 1000 population effluent system cost is approximately $138,000.

Wastewater Summary

Total wastewater costs per 1,000 population are shown below.

Sewers	$1,012,000
Treatment	500,000
Effluent	138,000
Total	**$1,650,000**

WATER SYSTEM

A water system for any area consists of the following elements.

- Distribution System
- Treatment

These water system elements are described below.

Distribution System

A distribution system consists of pipelines to distribute the water, booster pumps to maintain pressure and storage tanks to meet peak demands. As in the sewer system, the distribution systems of several communities were analyzed to determine the length per 1,000 population as well as the breakdown by diameter. Table 2, Typical Water System Per 1,000 Population, shows the result of the city analysis of the water systems.

Table 2 Typical Water System Per 1,000 Population
MAG Technical Memorandum– Infrastructure Development Costs

Diameter (inches)	Length (feet)	Unit Cost ($/lin ft)	Total Cost ($)
8	11,242	30	$371,000
10	4,784	36	189,500
12	3,109	47	160,800
16	1,913	60	126,300
18	1,435	73	115,200
20	957	84	88,400
24	145	97	15,500
30	130	138	19,700
36	120	163	21,400
48	80	222	19,500
Totals	**23,915**		**$1,127,300**

As can be seen from the table, the most common line size is the smaller 8-inch diameter. This is, for most communities, the smallest water line now approved for installation. The unit costs in the table are typical for the metropolitan area.

In communities which are relatively flat, booster pump stations are required in the system to move the water around and to maintain pressures. When there is no elevated storage, these booster stations need to have a pumping capacity equal to the peak hour flow. Using the same 100,000 population with a water demand of 200 gallons per capita per day, the average daily water demand will be 20 mgd. In such a typical system, the peak hour flow rate factor is 2.5. This means the peak hour flow in the system will be 50 mgd and the booster pump stations will have to pump this flow. If it is assumed that there will be 10 stations, each station will have a capacity of 5 mgd. The total cost of these stations for the system will be about $7,750,000. For each 1,000 population, the cost would be $77,500.

For storage tanks the needs are slightly different. Generally, the production capabilities will be designed to meet maximum day demand. The difference between the peak hour demand and the maximum day demand is made up from the storage reservoirs in the system. For the “typical” 100,000 community, this means a storage volume of about 5 million gallons. The cost of the storage would be approximately $1,890,000, giving a cost per 1,000 population of $18,900.

The distribution cost would be:

Pipelines	$1,127,300
Booster stations	77,500
Storage tanks	18,900
Total distribution system per 1,000	**$1,223,700**

Treatment

Communities have the option of supplying the water from groundwater via wells or from surface water. For the purposes of this analysis, it was assumed that surface water would be used. This would require a treatment plant to treat the water and also to treat the residual solids. Assuming that the plant would have conventional treatment with pre-sedimentation, chemical addition, coagulation, sedimentation, filtration and disinfection, the cost of a plant for 100,000 population would be about $70,000,000. The plant would be sized to meet maximum day demand of 35 mgd. For 1,000 people the treatment cost would be $700,000.

Water Summary

The total water system costs per 1,000 population are shown below.

Distribution	$1,224,000
Treatment	700,000
Total	**$1,924,000**

SOLID WASTE

Unlike water and sewer systems, which are basically similar for all communities, a solid waste system varies somewhat for each community. A solid waste system for a community can range from a fleet of collection vehicles that collect and transport the garbage to a regional landfill, to a system that includes collection vehicles, transfer station, long haul transfer vehicles and a community landfill. The majority of the communities in the metropolitan area only have collection vehicles and transport the wastes to local area public and private landfills. Communities with landfills include Phoenix, Glendale, and Chandler. Communities with transfer stations include Phoenix, Scottsdale, and Glendale.

Chandler is planning to close its landfill within the next few years. It will be replaced with a transfer station, which will transfer the garbage to one of the existing landfills in the area. Gilbert may build a transfer station to handle the population growth in the south service area. Phoenix is planning to close its existing landfill and replace it with a new landfill. Phoenix is also planning a new transfer station and recycling plant to handle the garbage from the north service area. With the large number of public and private landfills in the metropolitan area, it is unlikely that any other communities will be constructing a landfill in the near future.

Therefore, for the majority of the communities in the area little infrastructure is actually required for solid waste operation. The capital costs that are incurred result, from the purchase of additional residential and brush collection vehicles. The majority of the other costs are operational and maintenance related. These include drivers, mechanics, gas, truck maintenance, insurance, etc. One other major cost is landfill tipping fees if the community does not have its own landfill. This tipping fee can range from $20 to $30 per ton.

Based on the data generated, the cost to provide collection and brush vehicles is about $28,000 per 1000 people. If a transfer station is constructed for the 100,000 population, it could cost about $10,000,000. This would give a cost of $100,000 per 1000 population.

Summary

Collection	$ 28,000
Transfer Station	100,000
Total solid waste cost per 1,000	**$128,000**

COST CALCULATIONS

Note: Costs based on ENR Construction Cost Index of 6281 – January 2001

WASTEWATER SYSTEM COSTS

Sewers

Assumption: Cost /inch diameter per linear foot $5.00

Diameter	Unit Cost	Length	Cost
8	$40.00	14,177	$567,080
10	$50.00	1,323	$66,150
12	$60.00	798	$47,880
15	$75.00	662	$49,650
18	$90.00	416	$37,440
21	$105.00	378	$39,690
24	$120.00	284	$34,080
27	$135.00	236	$31,860
30	$150.00	189	$28,350
33	$165.00	170	$28,050
36	$180.00	104	$18,720
42	$210.00	95	$19,950
48	$240.00	85	$20,400
Total Cost/1000 population		**18,917**	**$989,300**

Lift Station 5 mgd

Assumption:	5 mgd station at $/MG/day	$200,000
Station Cost		$1,000,000
Cost/1,000 pop		$22,851

WWTP

Assumption:	10 mgd WRF Facility Unit Cost including sludge handling, $/gallon	$5.00
Plant Cost for 100,000		$50,000,000
Cost/1,000 pop		$500,000

Effluent System

		$/MG/day	Cost
Pump Station	10 mgd	$140,000	$1,400,000
Cost/ 1000 pop			$14,000
Distribution			
24			$1,713,000
12			$135,000
12			$264,000
12			$200,000
36			$1,330,000
36			$2,752,000
	Sub Total		$6,394,000
Cost/1000			$63,940

ASR Wells Assume 10 mgd system for 100,000 pop

Capacity mgd	0.5	Cost per well	$300,000
Number of wells	20		
Wells/1,000 pop			0.20
Well cost/1,000			$60,000

Summary

Sewers	$989,300
Lift Station	$22,851
Treatment	$500,000
Effluent Distribution	$63,940
ASR Wells	$60,000
Effluent P.S.	$14,000
Wastewater Cost/1000 Population	**$1,650,091**

WATER SYSTEM COSTS

Diameter	Unit Cost $/ln ft SRPMIC x 10%	Length (feet)	Cost	SRPMIC Costs*
8	33	11,242	$370,986	30
10	40	4,784	$189,446	36
12	52	3,109	$160,756	47
16	66	1,913	$126,289	60
18	80	1,435	$115,239	73
20	92	957	$88,402	84
24	107	145	$15,472	97
27	130		---	118
30	152	130	$19,734	138
36	179	120	$21,443	163
42	213	0	---	194
48	244	80	$19,536	222
54				
Total Cost/1000 Population		**23,915**	**$1,127,303**	

* SRPMIC Costs from recent utility evaluation/plan by Carollo Engineers for Salt River Maricopa Indian Community

Booster Pump Station

Assumptions

Population	gpcd	AD Flow, mgd	Peak Hour Ratio	Peak Hour Flow mgd	Stations	Stn Size mgd
100,000	200	20	2.5	50	5	10

Station Unit Cost	$/MG/day	$155,000
Total Cost		$7,750,000
Cost/1,000		$77,500

Storage Tanks

Assumptions

Population	gpcd	AD Flow, mgd	Peak Hour Ratio	Peak Hour Flow mgd	Stations	Stn Size mgd
100,000	200	20	2.5	50	1.7	34

Operational Storage (Peak-max for 3 hours) MG	2
% max day	3.4
Total Storage MG	5.4
Storage Unit Cost $/MG	$350,000
Total Cost	$1,890,000
Cost/1000	$18,900

Treatment

Assumption	Plant to meet max day, mgd	
Unit Cost	$/gallon	$2.0
Total Cost		$70,000,000
Cost/1000		$700,000

Summary

Distribution	$1,127,303
Booster Stations	$77,500
Storage	$18,900
Treatment	$700,000
Total Water Cost/1000	**$1,923,703**

Carollo Engineers (Carollo) has no control over the cost of labor, materials, equipment or services furnished by others in developing new infrastructure. Cost estimates are based on Carollo's opinion based on experience and judgment. Carollo cannot and does not guarantee that actual infrastructure development costs will not vary from cost estimates prepared by Carollo.

INFORMATION SOURCE LIST

City of Glendale

Glenn Compton – telephone conversation – (623) 930-3633
water storage, booster stations, lift stations

Jeff Walker – telephone conversation – (623) 930-2713
water distribution lengths by size

Henry Alcaraz – telephone and FAX – (623) 930-2714
FAX – wastewater collection system – lengths by size

City of Mesa

Peter Knudson – telephone and FAX – (480) 644-2251
FAX – water and sewer systems – lengths by size

Lift Stations – City of Mesa Sewer Master Plan Update 1996
Brown and Caldwell

City of Scottsdale

E-mails from Scott Anderson and Rick Payne
scottanderson@ci.scottsdale.az.us
rpayne@ci.scottsdale.az.us
water and sewer lengths and number of lift stations
Number of booster stations – Carollo in-house water master plan modeling

City of Peoria

Engineering Mapping Solutions – telephone and FAX – (602) 870-7811
water and sewer lengths by size data

Mel Huntspon – telephone – (623) 773-7475
booster stations and storage

Town of Gilbert

Water and sewer lengths by size
Carollo – in-house Water and Sewer Master Plan Updates

City of Phoenix

Gary Griffith – telephone – (602) 261-8363
lift stations

Sue Davidson – telephone and FAX – (602) 262=6479
water and sewer lengths by size.